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VICTOREEN INSTRUCTION MANUAL

Audeton, Model 376

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INTRODUCTION

The demand for a dependable radiation detector of the "personal variety" has long been axiomatic in nuclear physics circles. This urgent and obvious need has been responsible for the development of the pocket audio detector depicted in this report, which is a comprehensive summary of experimental results obtained during the development of this project. Included in the body of the report are photographs, charts, schematic diagrams, and service notes of the salient features produced in the finished detector. The terminal section contains an analysis of the conclusions and recommendations pertaining to future refinements of the various design factors.

In formulating the original design, an attempt was made to provide a light weight, compact, and reliable instrument possessing sufficient flexibility to be applicable to the multitude of monitoring details which do not warrant a complete quantitative measurement or for those surveys which are beyond the scope of the cumbersome and expensive laboratory meters. In its final form the detector consists of a gamma-sensitive subminiature Geiger tube together with all associated circuit components housed in a pocket-size case of such design that in appearance and operation the unit closely simulates the familiar hearing-aid receiver. The conventional ear-mold-insert transducer is employed to provide oral indication of the signal magnitude.

The inherent simplicity of the requirements of an audio detector presented an opportunity for a radical departure from conventional designs in a manner which adds appreciably to the intrinsic value of the instrument.

Results obtained from the experimental model have been entirely satisfactory and completely substantiate the feasibility of the basic principles involved. Proper pursual and exploitation of these principles should produce an instrument worthy of filling the heretofore unpervaded gap in the instrumentation field.

SPECIFICATIONS

Physical Characteristics

Height, 6 in.
Width, 3 in.
Depth, 1⅛ in.
Weight, 1 lb, 10 oz.
Case material, cast aluminum
Finish, chromic anodizing, flat-gray paint
Construction, splashproof
Accessories, individual ear molds (right or left), carrying strap (optional)

Electrical Characteristics

Operating voltage, adjustable 0 to 450
Nominal generator frequency, 150 cycles
Output impedance, 30 ohms

Earphone impedance, 30 ohms (magnetic type)
Generator coil, 700 turns No. 30 enameled wire
Coil resistance, 10 ohms
Transformer. Turns ratio, 150/1
Resistance (primary), 10 ohms
Resistance (secondary), 9000 ohms
Inductance (primary), 130 mh
Inductance (secondary), 290 h
Rectifier. Forward resistance, 1.5 meg ohms at 15 volts
Back resistance, 500 meg ohms at 15 volts

Characteristics of Geiger Tube

Type, VG-7
Bulb, T-3
Length, 3½ in.
Filling, methylene, bromide, and argon
Plateau length, approximately 30 volts
Plateau slope, approximately 10 per cent
Background, approximately 25 cts/min
Temperature range, +135 to −30°F
Life, approximately 5×10^7 counts

Performance Characteristics

Operating time, approximately 2 hr per charge at background counting rate
Indicator, magnetic earphone
Sensitivity, gamma. Any intensity greater than average background rate is detectable.
Calibration. Accuracy of calibration is contingent upon an estimate of the counting rate and will vary with aptitude and experience of the individual operator.

GENERAL DESCRIPTION

The pocket audio detector is a gamma-sensitive instrument consisting of a special subminiature Geiger tube, power unit, matching network, and miniature insert-type earphone. All components, with the exception of the earphone, are housed in a pocket-size aluminum case simulating the appearance of the familiar vest-pocket hearing-aid receiver. This construction lends itself admirably to a variety of applications, and the extreme compactness allows the unit to be worn for long periods of time without undue fatigue to the operator.

Energy to operate the detector is stored in a special tank condenser which is periodically recharged by a self-contained spring-actuated generator. The storage capacity of this condenser is sufficient to operate the circuit for a period of time far in excess of that necessary to complete the average survey. For extended periods of operation the generator may be recycled as often as necessary.

Normal operation of the detector is indicated by an audible signal (approximately 25 cts/min) produced at a comfortable level in the earphone. As the counter is exposed to radiation, with a consequent increase in counting rate, the effective acoustical level produced by the earphone likewise increases, thereby producing maximum signal volume at a time when it is most needed. An approximation of the radiation intensity can be gained by estimating the frequency (average counting rate) of the audio signal as heard in the earphone.

CIRCUIT DESCRIPTION

Tank Condenser

The circuit arrangement chosen as most suitable for the final model of the detector is a composite of several designs tested during the development stages and is shown in complete schematic form in Fig. 7.

Successful operation of the counter depends upon the storage capacity of its tank condenser (101). Assuming infinite leakage resistance in the condenser itself, the discharge rate would be entirely a function of the energy expended in the Geiger tube which for the type VG-7 is approximately 6×10^{-10} coulomb per pulse (expressed as a mean value since the individual pulse charge is a function of the overvoltage of the tubes).

Under these theoretical conditions the operating time for a single charge of the condenser would be determined by the useful plateau length of the Geiger tube and its average counting rate during the operating period. Thus a charge of 5 microcoulombs, a plateau length of 50 volts, and an average counting rate of 25 cts/min would give a total operating time per charge of 5 hr and 30 min. Obviously, this theoretical value cannot be achieved in actual practice since a practical tank condenser must necessarily be a compromise of size, capacity, voltage rating, and internal leakage resistance.

Commercially available condensers were found to be unsuitable with an approximate leakage resistance of only 1×10^{12} ohms. Extensive research with various dielectrics resulted in a sizable improvement in this value. The final selection was a styrene dielectric condenser of 0.1-μf capacity and a 450-volt operating test, housed in a hermetically sealed container with connections terminated through Kovar-glass seals. Total leakage of the finished unit was found to be approximately 2×10^{13} ohms. Additional protection to the surface resistivity of the glass seals and the press of the Geiger tube was provided by processing their surfaces with silicone varnish dry film.

A leakage resistance of this order of magnitude provides an average operating time of nearly 2 hr, which can be considered satisfactory for all normal demands likely to be made of the instrument.

Geiger Tube

The type VG-7 Geiger tube illustrated in Fig. 8 has been developed specifically for use in the pocket audio detector and is a methylene-bromide-argon self-quenched filling. A typical plateau curve is shown in Fig. 9. The operating region of 300 volts was selected to be consistent with the available circuit parameters. Operation in this region somewhat limits the available pulse amplitude; however, the average height, Fig. 10, over the usable portion of the plateau was found to be more than adequate.

The use of a seemingly desirable plug-in base instead of the flat lead press has been purposely avoided in order to maintain an extremely high leakage pass across the lead press, since a low resistivity (either volume or surface) at this point means a serious loss of condenser charge which would result in an appreciable decrease of unit operation time.

It will be noticed that a considerable increase in tube efficiency will be experienced over the life span, see Fig. 13. This effect can be ignored for all practical purposes, since measurements made with the instrument are of a qualitative nature only.

Output Circuit

A special coupling transformer (102) is utilized to provide the necessary impedance matching between Geiger tube and earphone. At the same time, a frequency-conversion effect is obtained by proper coil construction and choice of lamination material. This conversion is necessary since the energy distribution of the extremely narrow tube pulse is confined to a portion of the spectrum beyond the response limit of the earphone, indicated in Fig. 14.

After conversion the pulse as measured at the receiver input appears as illustrated in Fig. 16 and contains adequate power to drive the earphone at normal loudness (approximately four bars into a 2-cc cavity) for the average listener.

Virtually automatic control of the volume is accomplished by the relative increase in effective acoustical power with increase in counting rate as shown in Fig. 17.

High Impedance Output

An alternative output circuit arrangement applicable to surveys involving unusually high counting rates is diagrammed in Fig. 18 and operates in the following manner.

Supply voltage E_B is made equal to the Geiger-tube operating voltage V_0 plus the striking potential of neon tube N.

Conduction of the Geiger tube allows the series capacity combination of condenser C and earphone R (crystal type) to accumulate a voltage charge at a rate determined by the average counting rate of the Geiger tube until voltage e reaches the ignition potential of neon tube N. Conduction N discharges network RC until voltage e is again reduced to the extinction potential of tube N. During the conduction period the current decay through network RC produces an audible pulse of saw-tooth shape and considerable amplitude in receiver R.

This output pulse varies with the counting rate of the Geiger tube at a dividing ratio of approximately 80/1, see Fig. 19, thereby enabling the operator to estimate small percentage changes at the higher counting rates.

In addition to the extremely large output signal provided, this arrangement has the additional advantage of requiring no output transformer, which would mean a considerable saving in weight as well as component cost.

Generator

Figure 20 shows an assembled view of the completed generator. For clarity of assembly plus a thorough understanding of its operation, an exploded view of the same generator is given in Fig. 21. Energy to actuate the mechanism is derived from the preloaded mainspring (114). Several preloading turns are given the spring barrel in order to place the operating point at the upper, or maximum, portion of the curve for the spring power output, Fig. 22, thereby obtaining maximum operating torque. Withdrawal of the pull string (115) gives the spring barrel a differential operating torque of two additional revolutions, at the same time disengaging the brake arm (210).

Upon release of the pull string the spring's operating torque is transmitted to the magnetic rotor (105) which is coupled to the spring barrel through ratchet and pawl (224) and a step-up gear train (ratchet slips in the winding direction), thus accelerating the rotor until it has reached maximum speed. Unwinding of the spring barrel allows the brake arm (210), which is controlled by a spiral cam (225), to again engage the brake drum (229) attached to the rotor shaft (218) thereby retarding further rotation of the rotor. (Braking is applied at this low torque point in order to relieve the cam, which operates at high torque, of any undue stress.) The generator is then ready to be recycled.

After the spring barrel has come to rest, the string mandrel continues to rotate part of a revolution due to the action of its own driving spring (217). This action tends to keep a constant tension on the pull string, thereby holding the plastic ball tightly against the O-ring seal.

The extra excursion of the string mandrel at the start of the unwinding cycle provides a slight impact to the spring barrel and assists the main spring in overcoming the "dead center drag" imposed by the magnetic rotor.

Switch

In addition to the prime function of braking, the brake arm (210) also actuates the switch (108) through an actuating arm (207). The sequence of this operation is adjusted to operate the switch just previous to the application of the brake shoe, thus isolating the tank condenser from its voltage source and preventing partial discharge, which would otherwise occur through the supply impedance. It should be noted that the stationary switch contact (241) is supported entirely by the condenser terminal, an added precaution in maintaining a high circuit impedance at this point.

Signal output may be turned off at any time by withdrawing the generator pull string only halfway. This completely discharges the tank condenser thereby stopping counteraction.

Voltage Multiplier

Output from the generator, Fig. 24, is fed directly to the primary winding of a step-up transformer (102), the secondary of which supplies a voltage multiplying circuit consisting of rectifiers (106) and condensers (113). Output from the multiplier provides high-voltage direct current to charge the tank condenser and in turn to operate the Geiger tube.

In order to accommodate a wide range of Geiger-tube operating voltages, a semiadjustment of generator voltage is accomplished by the addition of a rotor shorting ring (230), the relative effects of which are given far different ring sizes in Fig. 26. Final and precise voltage adjustment is obtained by proper selection of a load resistor (111). (See Calibration Instructions.)

Voltage Regulation

Of particular interest is the manner in which voltage regulation is accomplished. The secondary winding of the transformer (102) in conjunction with the condenser (112) comprises a parallel resonant circuit tuned to the nominal generator frequency of approximately 150 cycles, as shown in Fig. 27. As a result of this resonance, automatic voltage limiting is obtained. Since maximum voltage is reached at the peak of resonance, further acceleration or deacceleration of the generator's rotor (change in output frequency) only results in decreased output voltage. Circuit loading, with its associated lowering of circuit Q, produces a broadening of the response curve, Fig. 27, and results in an output regulation curve as shown in Fig. 28.

MAINTENANCE AND REPAIR

Replacement of Geiger Tube

Replacement of a tube having a different operating voltage from that of a tube previously contained in the detector requires a complete recalibration of the voltage supply. The necessary instruments are (1) precision decade resistance box or 10-megohm variable resistance and (2) electrostatic voltmeter, 0 to 500 volts. These are connected at test points indicated on the wiring diagram, Fig. 29. Adjust the decade box to correspond with the approximate calibration-resistor value selected from Fig. 30; cycle generator and note voltmeter reading; readjust decade box, recycle generator, and observe new voltmeter reading. This procedure is repeated until proper operating voltage (previously ascertained from the tube plateau curve, Fig. 9) for the new tube is obtained.

CAUTION

Cycling of the generator without a calibration resistor in the circuit may cause serious damage to transformer or rectifiers.

A calibration resistor equivalent to the value indicated by the decade box is then soldered in place on the terminal strip. If a variable resistor is used instead of the decade box, this should be measured with an accurate bridge or ohmmeter.

Geiger tubes with an operating voltage equivalent to that of the tube being replaced may be used without repeating the calibration procedure as outlined above.

CAUTION

Handling of the Geiger-tube lead press or condenser seals should be avoided since contamination at these points may seriously impair their operation.

SPECIAL VOLTMETER

Substitution of a standard vacuum-tube voltmeter in lieu of the electrostatic type stipulated under Calibration Instructions will produce equally satisfactory results by the installation of a few simple

voltmeter circuit changes as shown in Fig. 31. After revision, the meter (with standard input probe) was found to have an input impedance of approximately 1×10^{11} ohms, which is at least an order of magnitude greater than necessary for this application.

Scale calibration curves for the converted meter are given in Fig. 32. The apparently serious departure from linearity is, in this case, relatively unimportant since only a single check point is needed for any particular Geiger tube. Meter calibration may be rechecked at any time against any low-impedance voltmeter.

Circuit values indicated in Fig. 31 are for the type 615-A RCA voltohmyst; however, comparable values will be found suitable for similar meters of other manufacture.

CASE DETAILS

Absence of assembly mounting screws makes removal of the major components an extremely simple operation. As shown in Figs. 20 and 21, all component assemblies are mounted in the bottom of the case and held in position by the top cover which is fastened with four flathead case bolts.

CAUTION

If for any reason either generator or tank condenser are removed from the case, a calibration check of the supply voltage will be necessary before again placing the unit in operation.

Two O-rings (107 and 119) are permanently cemented to the case to provide splashproof construction.

A strap fixture (239) is provided at the top of the case for attachment of a neck or wrist strap in the event it should be desirable to use the instrument for probe work.

The phone jack may be removed for repair by withdrawing its retaining yoke (237) and pressing the plug insert (236) toward the inside of the case.

SUMMARY

The detector described in this report is a composite of special custom-built components representing the most promising features of the many experimental types tested. This particular version should be evaluated merely as a prototype for an almost infinite variety of instruments which could advantageously utilize the basic principles established by this experimental work.

Particular attention is called to the case construction, since considerable saving of size and weight was sacrificed in order to preserve the similarity between this instrument and its counterpart, the hearing aid, and at the same time retain the features of reproducibility offered by the use of cast-aluminum cases and fabricated construction. These are not, however, serious objections, only experimental necessities, which are readily overcome by the adoption of molded plastic parts in the production design. Inclusion of a voltage supply capable of accommodating a high-voltage Geiger tube added further unnecessary bulk. With the advent of the type G-7 low-voltage tube, this reserve supply voltage had to be dissipated as wasted energy. Calculation of a condensed unit based upon these facts indicates a possible reduction of at least one-half in weight and one-third in size, with operating characteristics remaining unchanged.

It is recommended that hermetically sealed case construction be incorporated in any final design. This has been purposely avoided in the original as being a complexity unwarranted until the design parameters are more firmly established.

It should be fully appreciated by all who may examine this instrument that the various components contained therein have been subjected to rather strenuous laboratory treatment with a consequent suffering of individual characteristics. The results exhibited by these same components therefore do not necessarily constitute the ultimate which would otherwise be obtained.

Purchased Parts

Description	Manufacturer	Type	Quantity
Condenser 0.1 μf	John E. Fast & Co.	Special	1
Transformer	Electronic Transformer	5 - 2	1
G-M tube	Victoreen	D75	1
Receiver	Western Electric	724-A	1
Rotor	Indiana Steel	27547-A	1
Rectifier	Selenium Corporation	IN35F	3
O-ring	Linear, Inc.	MJ70-0	1
Switch	Micro Switch	YZ-2RS	1
Ear plug	M. L. Muir	4	1
Contact	Mallory	SC	1
Resistor	I R C	BT-1/2	1
Condenser 0.005	C-D	I D 5D5	1
Condenser 0.01	C-D	I D 3S1	2
Spring	Westclox	71	1
String			6 in.
Phone-plug contacts	Brush	106071SP	2
Case bolts		No. 4-40 × 3/8	4
Strap fixture bolts		No. 4-40 × 1/8	2
O-ring	Plastic & Rubber Products	902-2	1
Transformer	Electronic Transformer	5-2-400	1
Receiver cord	Western Electric		1

Fabricated Parts

Item	Description	Dwg. No.	Quantity
201	Bottom cover	M114-7	1
202	Top cover	M114-8	1
203	Coil form	M114-47	1
204	Calibration-resistor mount	M114-46	1
205	Stator laminations	M114-45	50
206	Switch mount	M114-42	1
207	Switch actuating arm	M114-41	1
208	Switch–actuating-arm insulator	M114-40	1
209	Switch alterations	M114-43	1
210	Brake arm	M114-39	1
211	Spacer	M114-38	1
212	Plate spacer	M114-37	1
213	Plate spacer	M114-36	1
214	Stator mounting stud	M114-35	1
215	Spacer	M114-34	2
216	Winding-drum stops	M114-33	4
217	Spring-barrel preload spring	M114-32	1
218	Rotor shaft	M114-17	1
219	Idler-shaft pinion	M114-22	1
220	Idler-shaft gear	M114-21	1
221	Spring-barrel gear	M114-31	1
222	Winding drum	M114-28	1
223	Spring-barrel cover	M114-29	1
224	Spring drive ratchet and pawl	M114-30	1 each
225	Spring barrel	M114-26	1
226	Spring-barrel shaft	M114-25	1
227	Spring-barrel shaft lock	M114-24	1
228	Idler-shaft screw	M114-23	1
229	Brake drum	M114-20	1
230	Rotor shorting ring	M114-19	1
231	Rotor alterations	M114-18	1
232	Top plate	M114-16	1
233	Bottom plate	M114-15	1
234	Terminal board	M114-14	1
235	Phone plug	M114-13	1
236	Phone-plug parts	M114-12	2
237	Phone-plug parts	M114-11	1
238	Ball	M114-18	1
239	Strap fixture	M114-9	1
240	Switch arm	M114-44	1
241	Condenser contact arm	M114-48	1

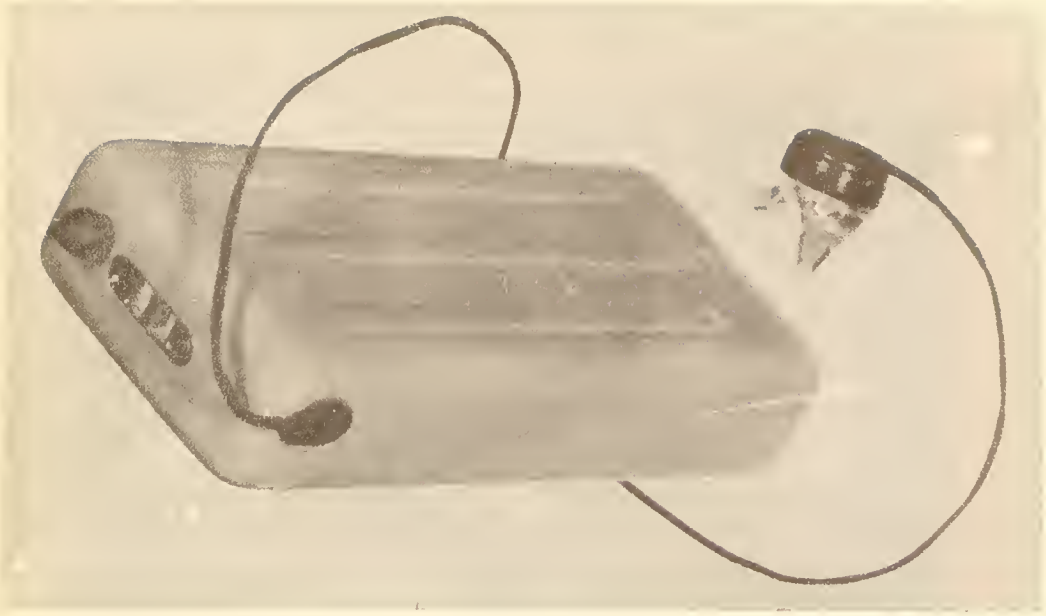

Fig. 1 — Complete instrument.

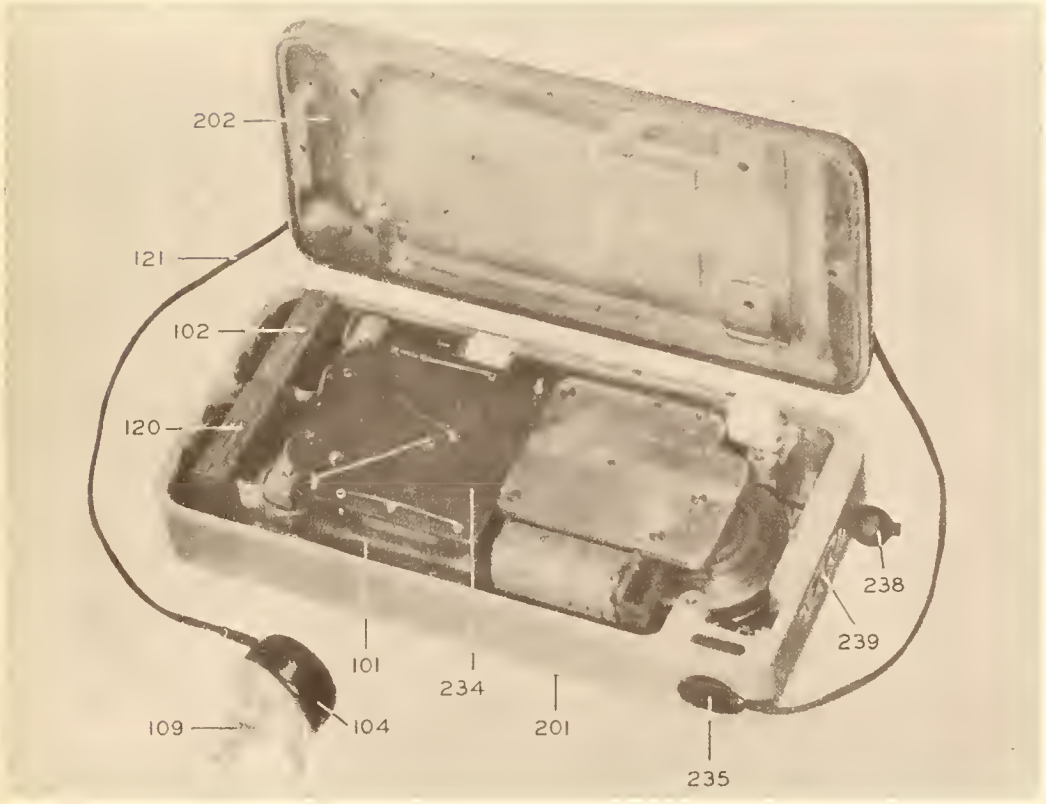

Fig. 2 — Complete instrument with cover removed.

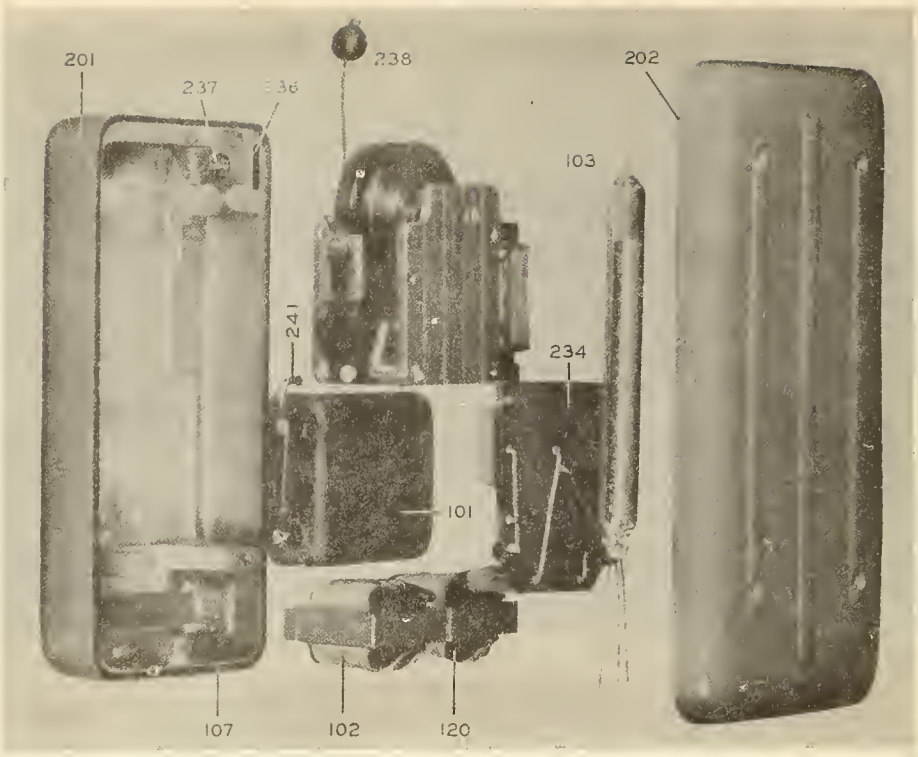

Fig. 3—Exploded view of instrument.

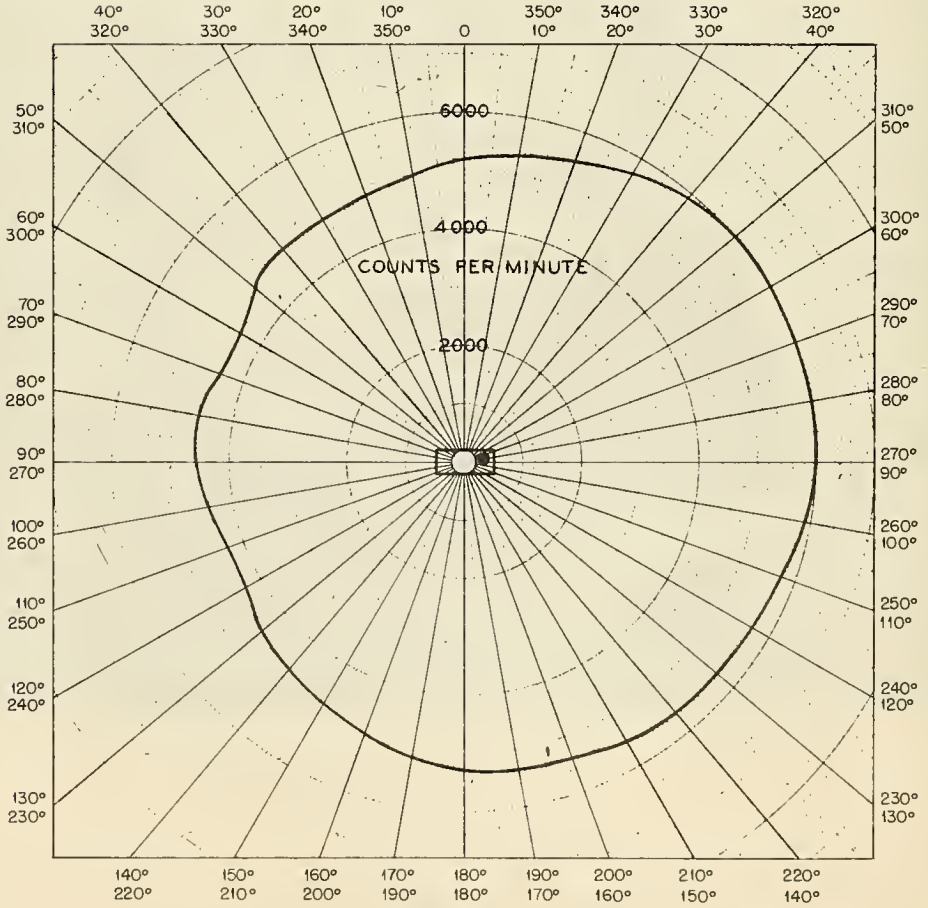

Fig. 4—Sensitivity field pattern, horizontal.

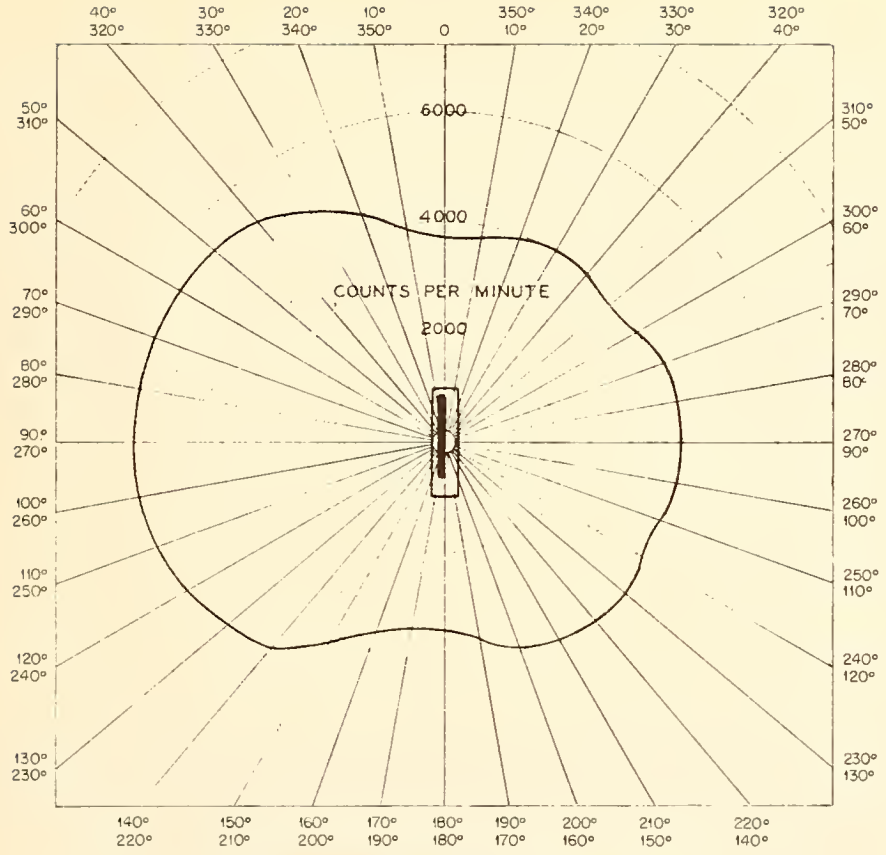

Fig. 5—Sensitivity field pattern, vertical edgewise.

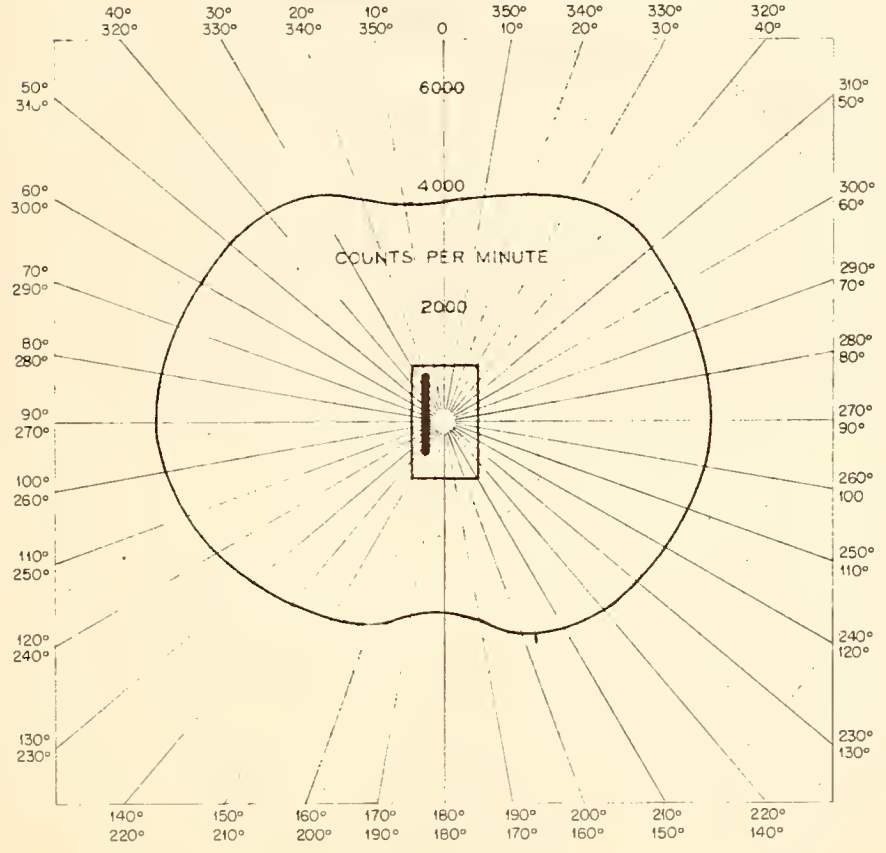

Fig. 6—Sensitivity field pattern, vertical broadside.

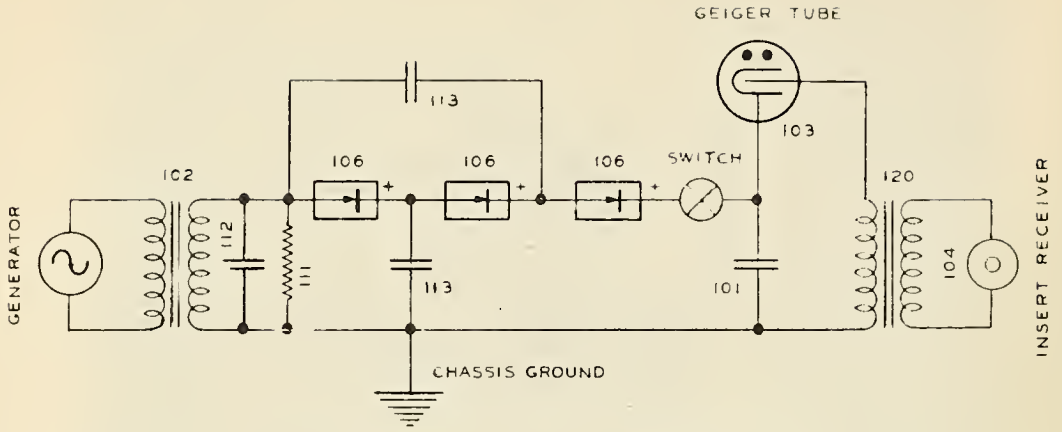

Fig. 7—Schematic diagram of audio detector.

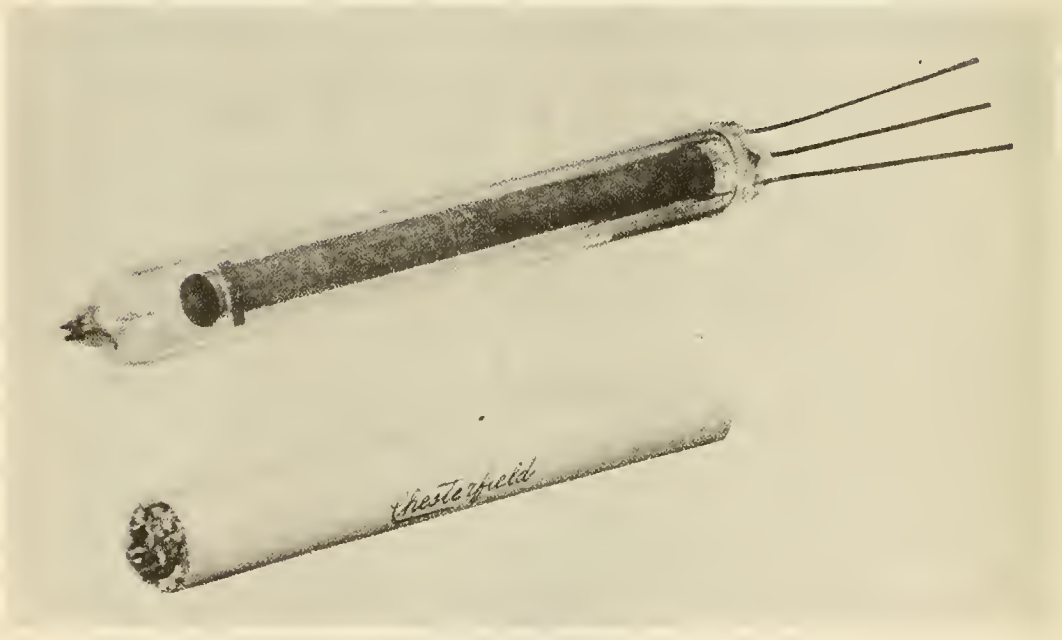

Fig. 8—Geiger tube.

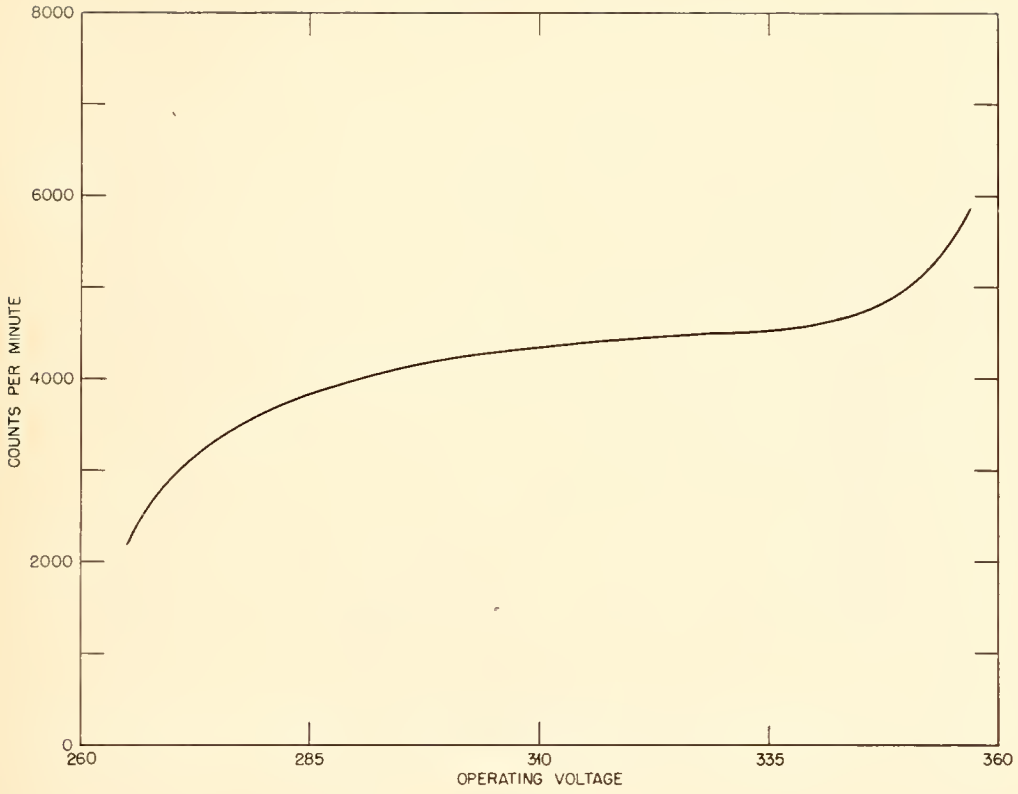

Fig. 9—Geiger-tube plateau.

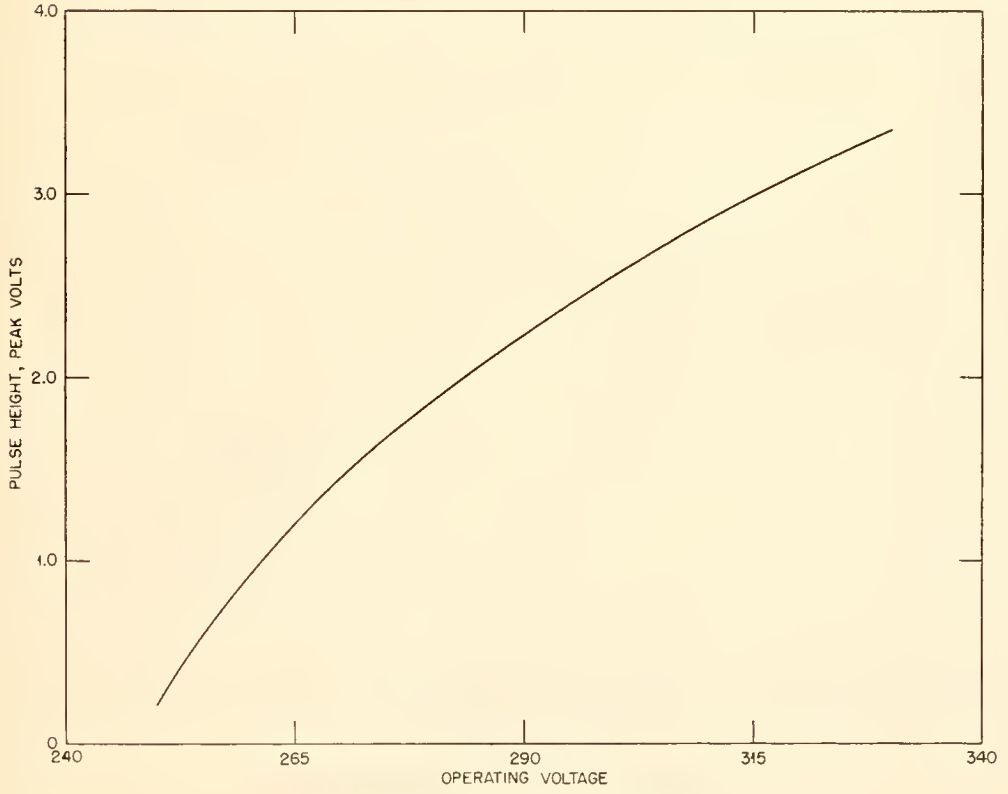

Fig. 10—Geiger-tube pulse amplitude.

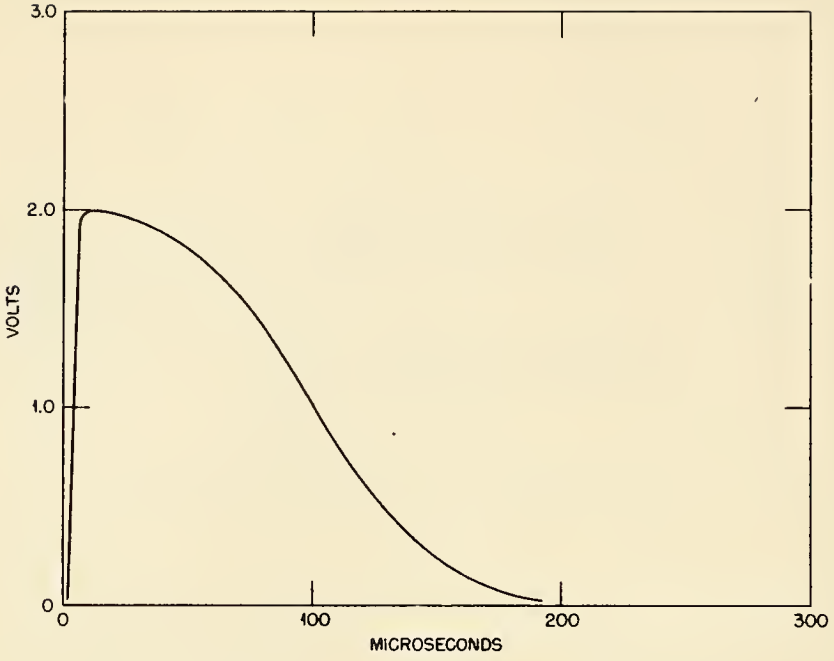

Fig. 11—Geiger-tube pulse shape.

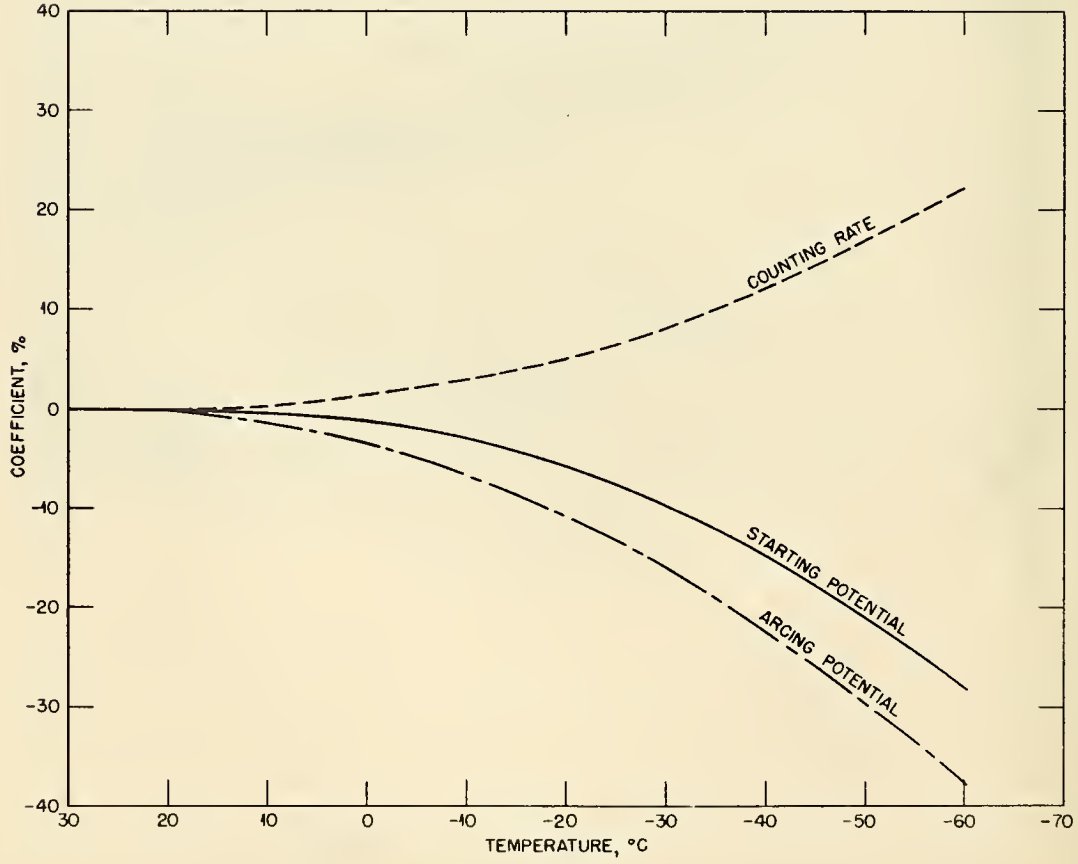

Fig. 12—Geiger-tube temperature coefficient.

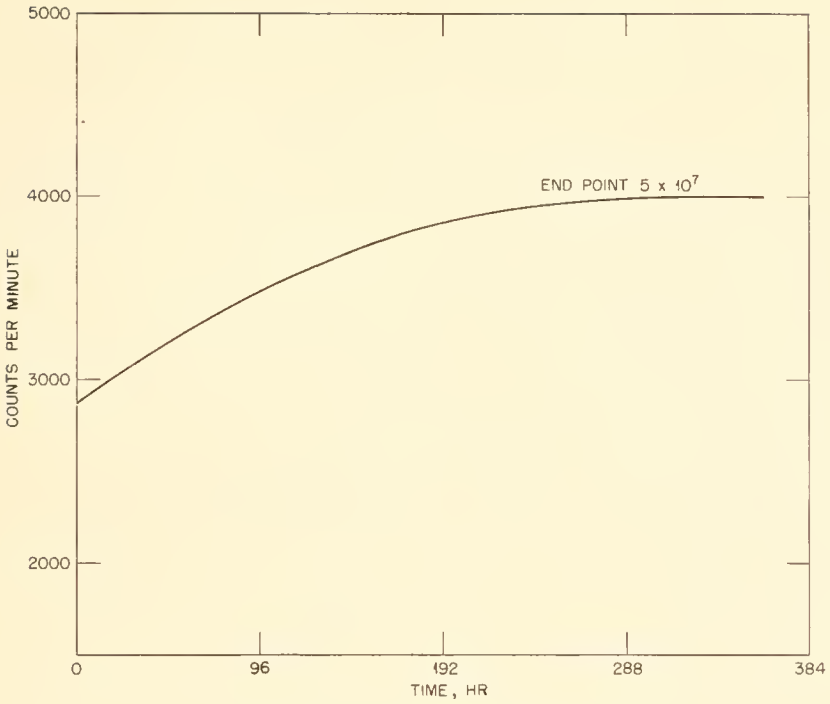

Fig. 13 — Test of Geiger-tube life.

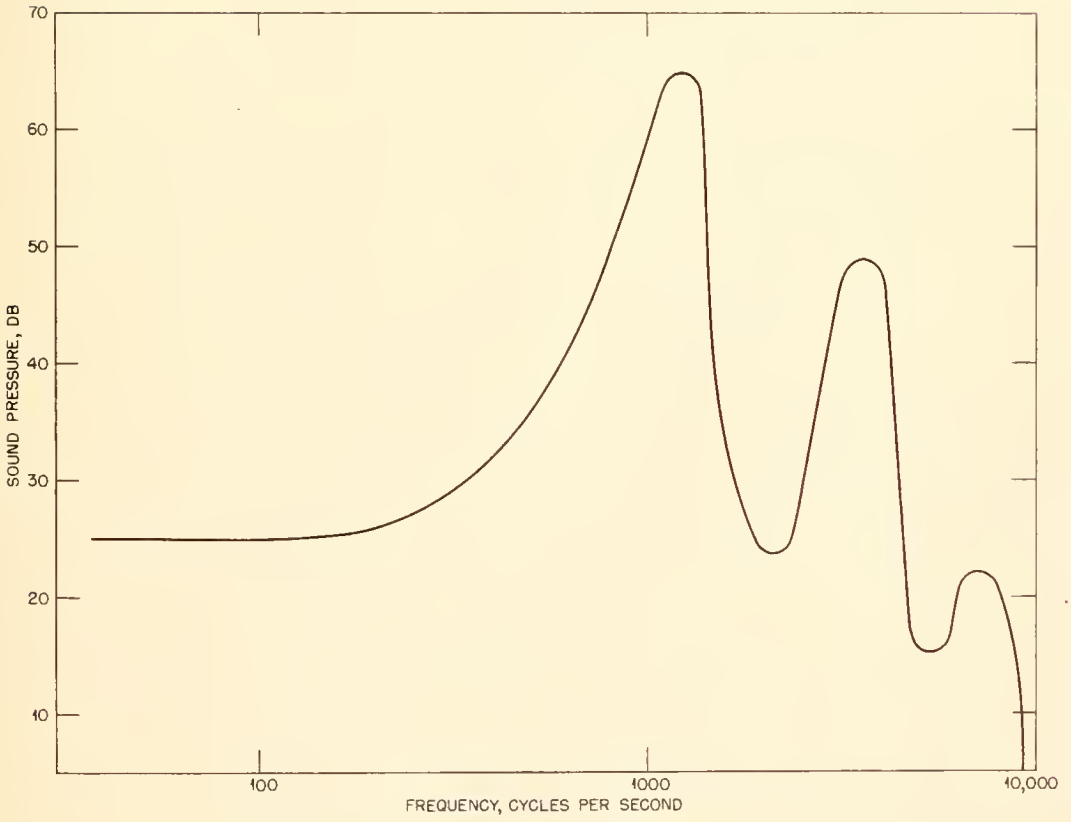

Fig. 14 — Curve for earphone response.

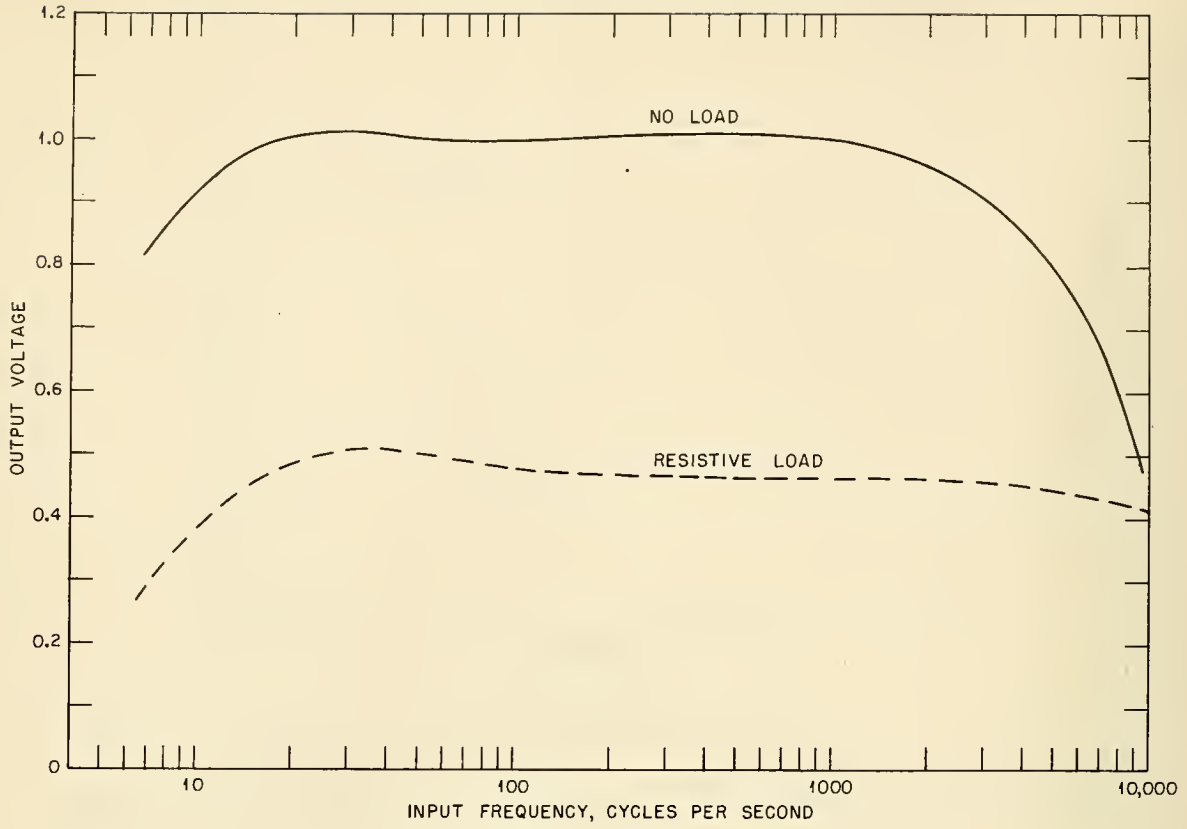

Fig. 15—Curve for transformer response.

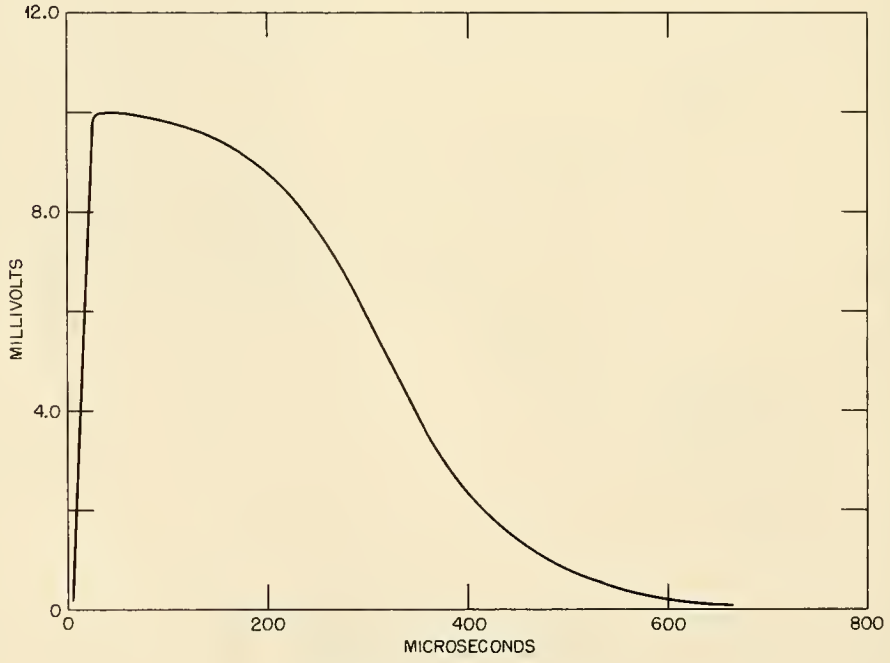

Fig. 16—Output-pulse shape.

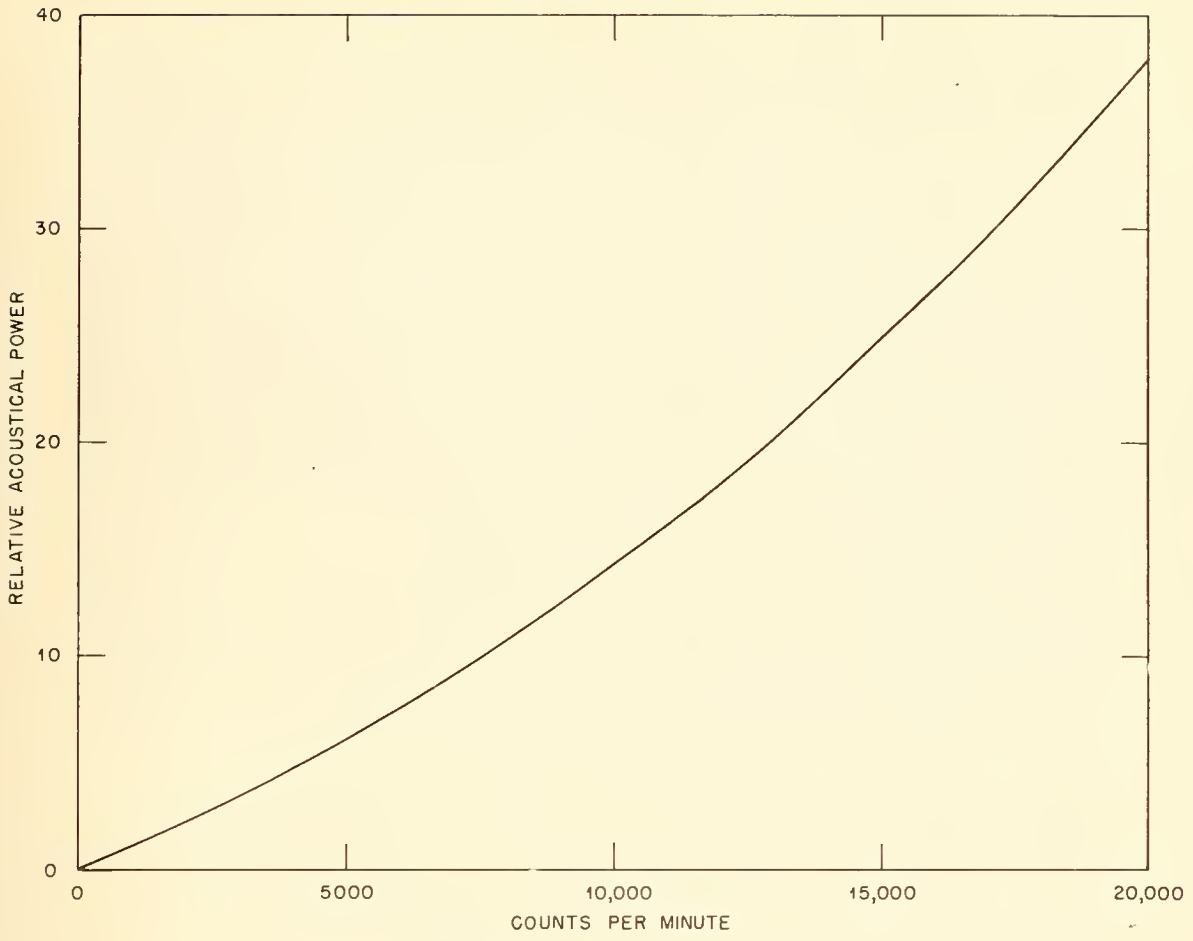

Fig. 17—Acoustical output.

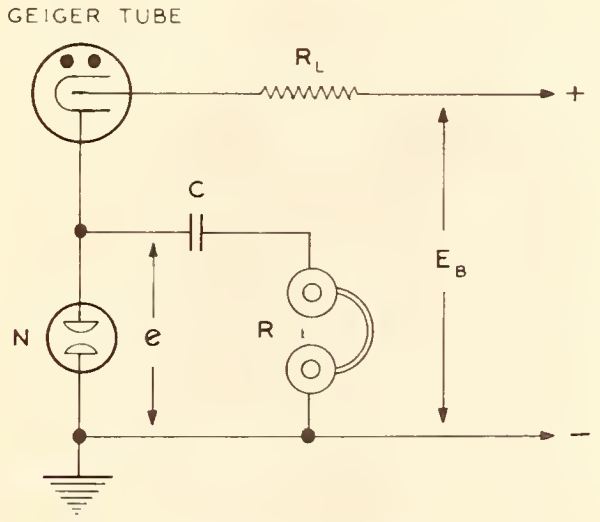

Fig. 18—Schematic diagram of output circuit.

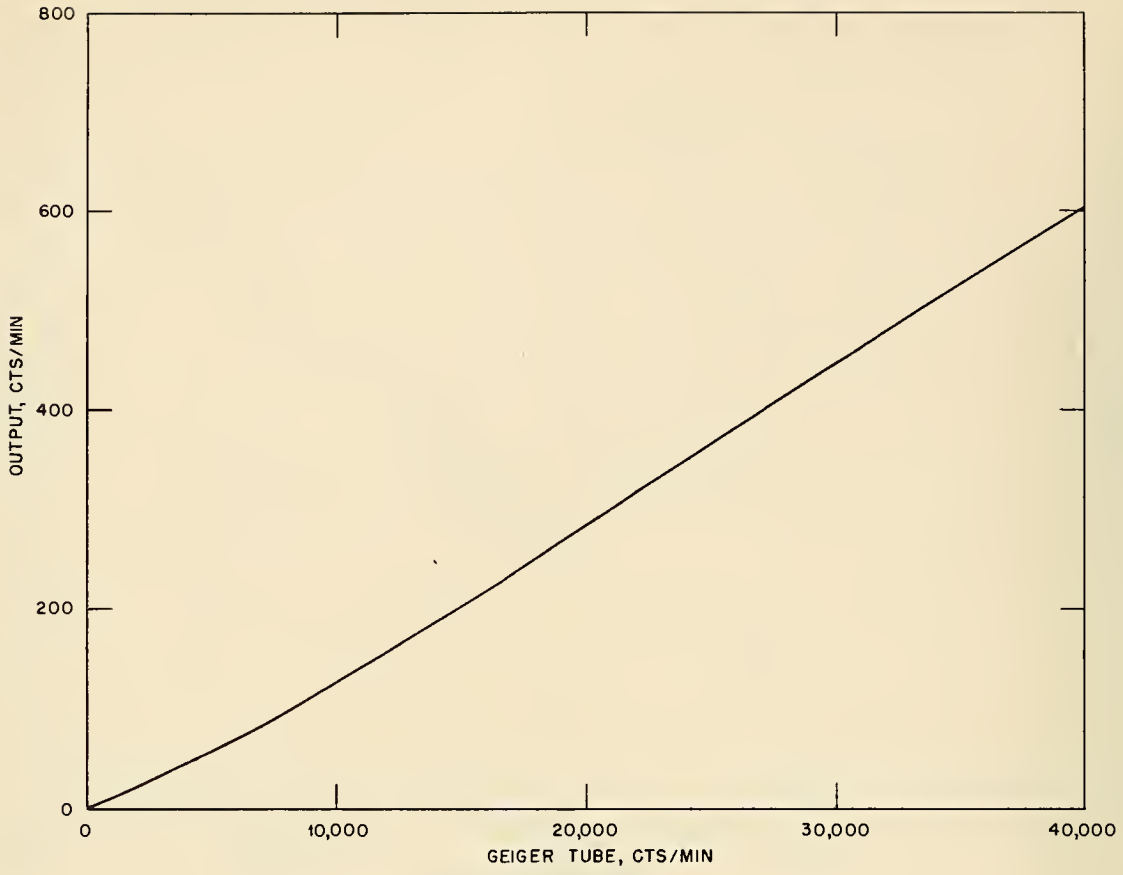

Fig. 19—Output dividing ratio.

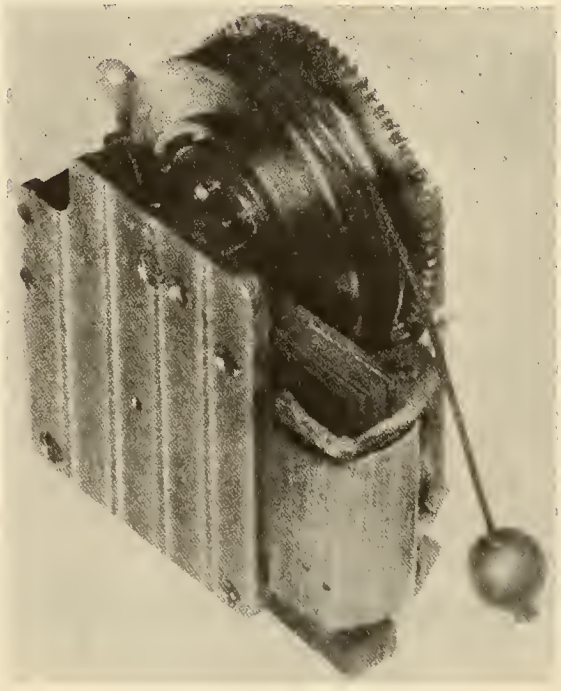

Fig. 20—Generator.

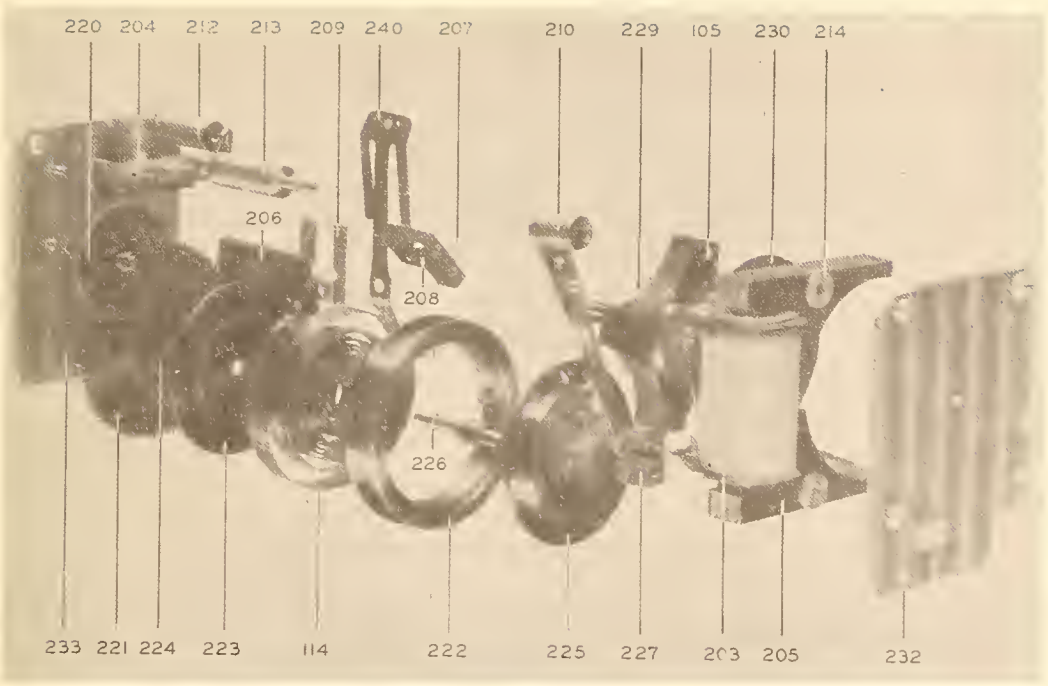

Fig. 21 — Exploded view of generator.

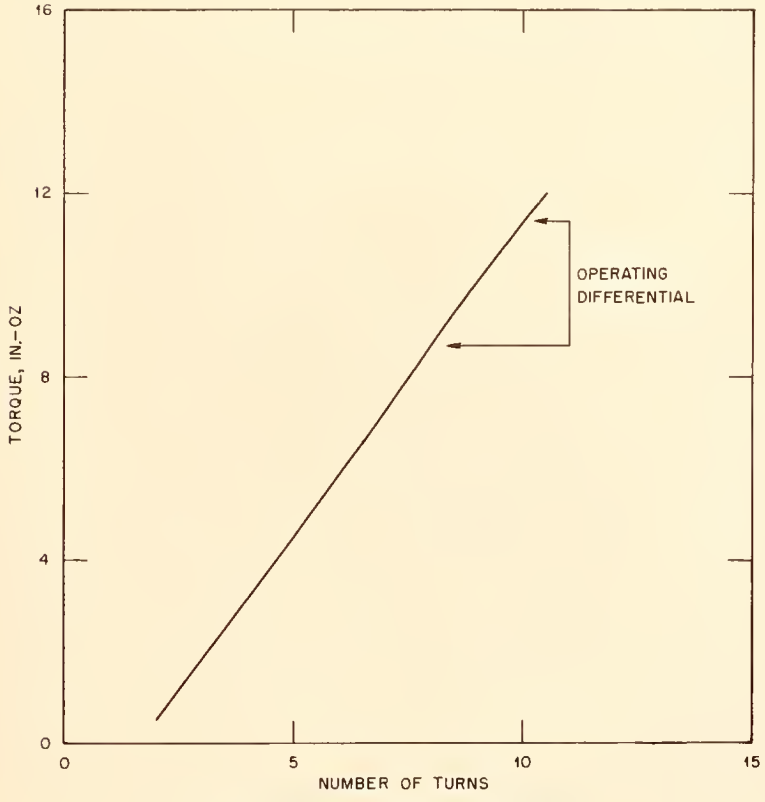

Fig. 22 — Power-output curve for spring.

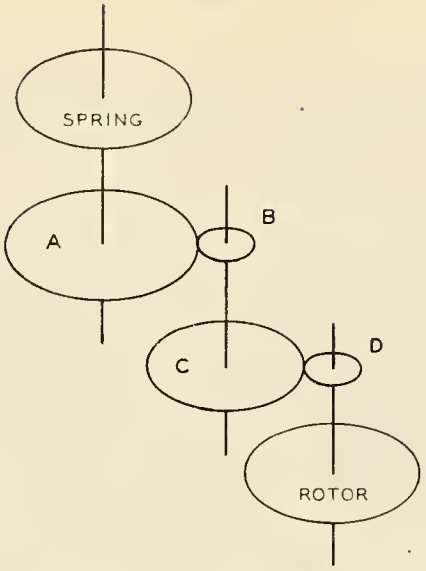

Fig. 23—Data for gear and coil. Ratio: 50.4/1.

Gear	Teeth	Pitch	
A	72	48	Standard tooth, 20-deg pressure angle. Center distance, 0.860.
B	10	48	Long addendum, 20-deg pressure angle. Center distance, 0.860.
C	56	64	Standard tooth, 20-deg pressure angle. Center distance, 0.570.
D	8	64	Long addendum, 20-deg pressure angle. Center distance, 0.570.

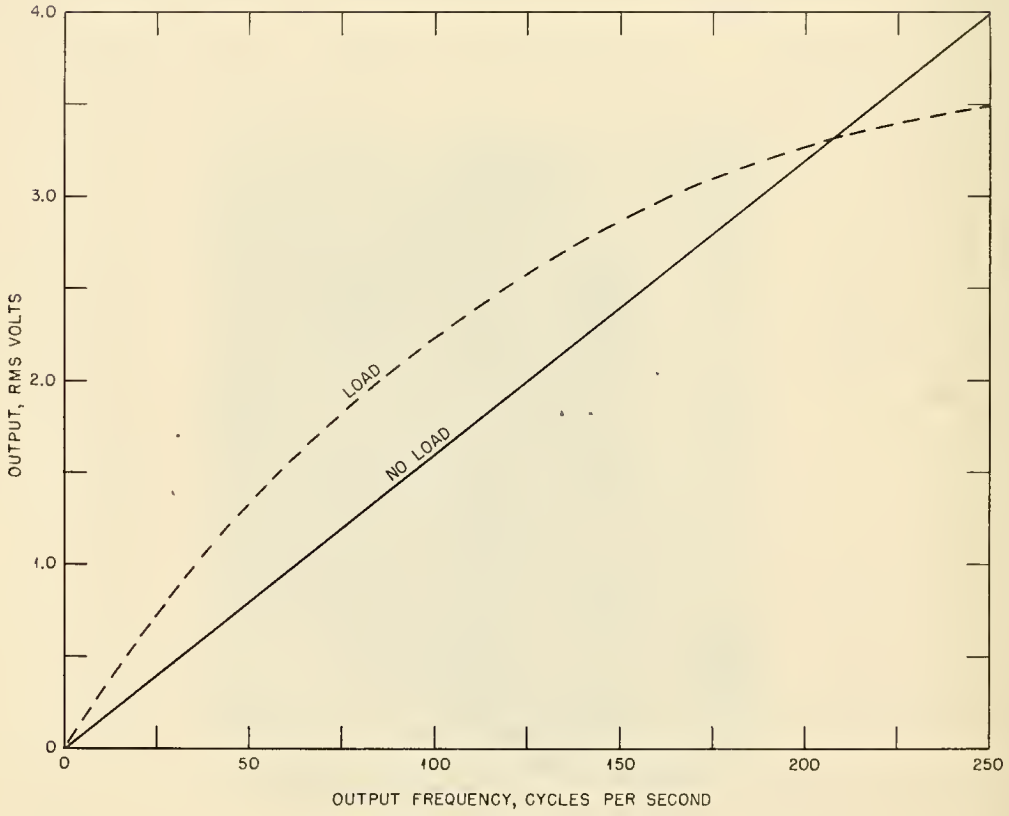

Fig. 24—Generator output voltage.

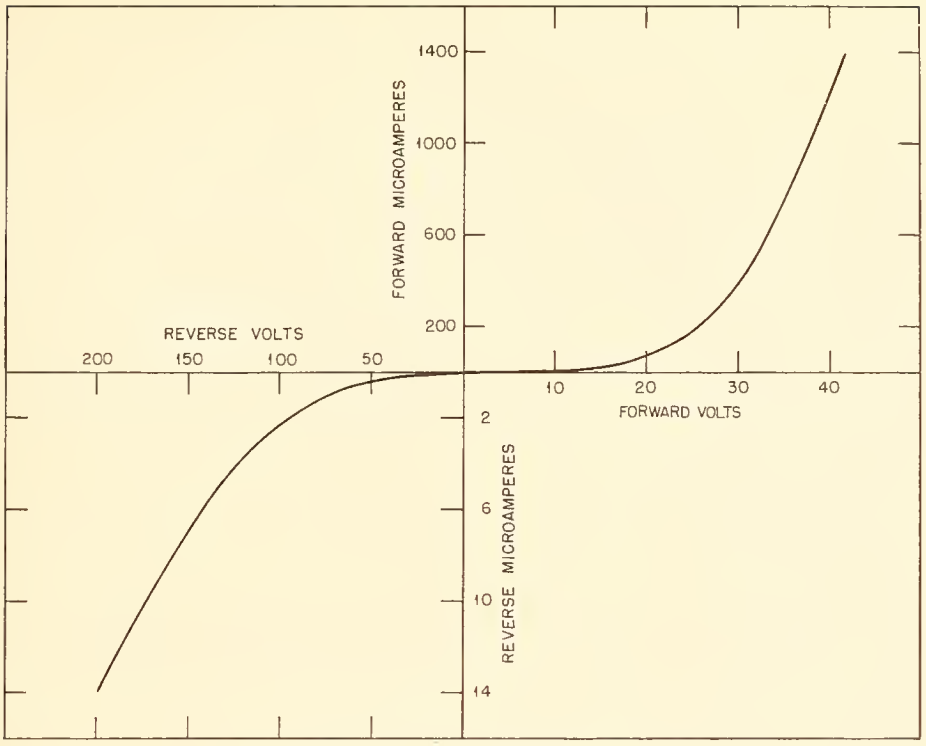

Fig. 25—Characteristics of static rectifier.

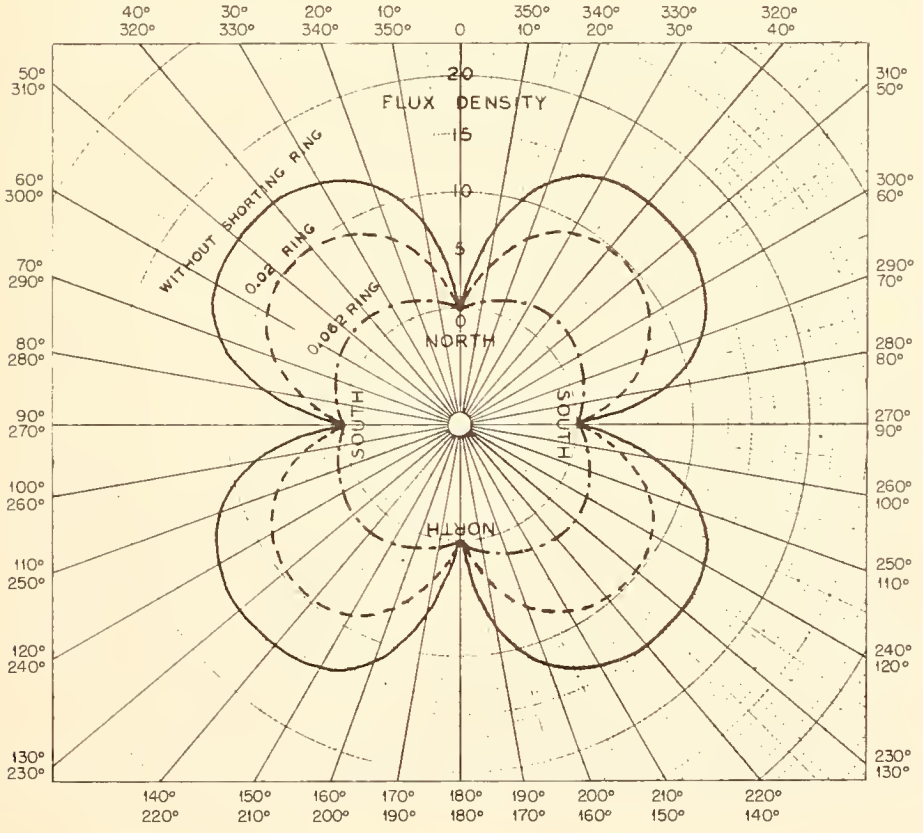

Fig. 26—Rotor-flux field pattern.

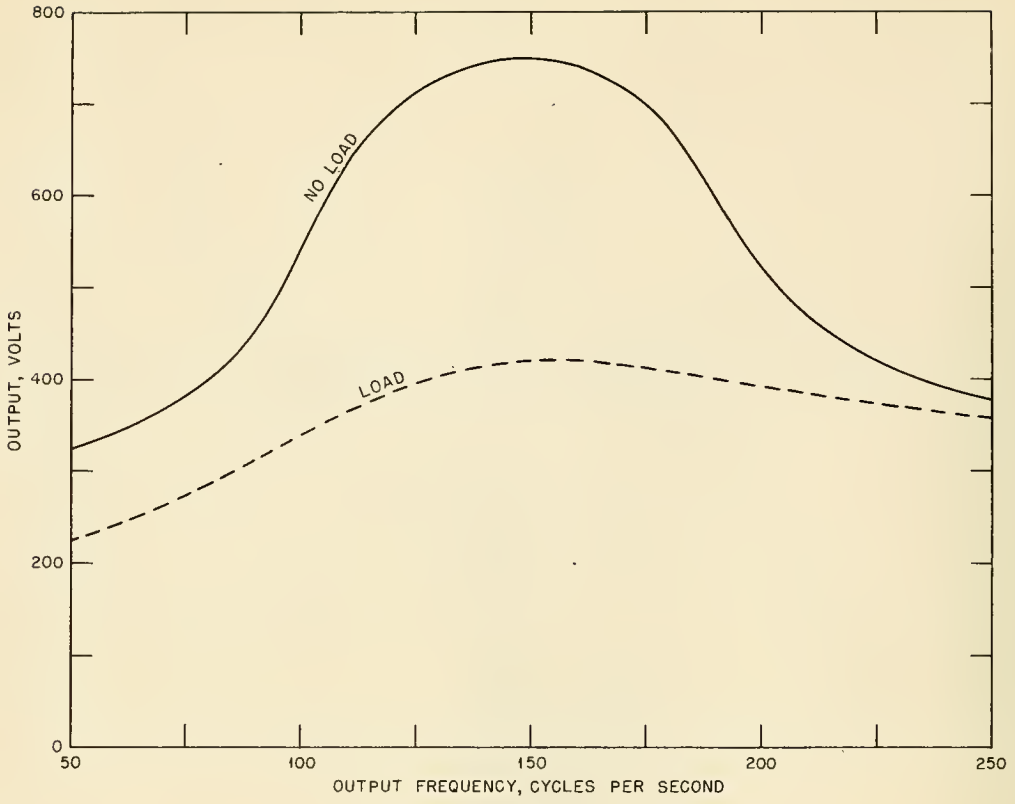

Fig. 27—Limiter resonance curve.

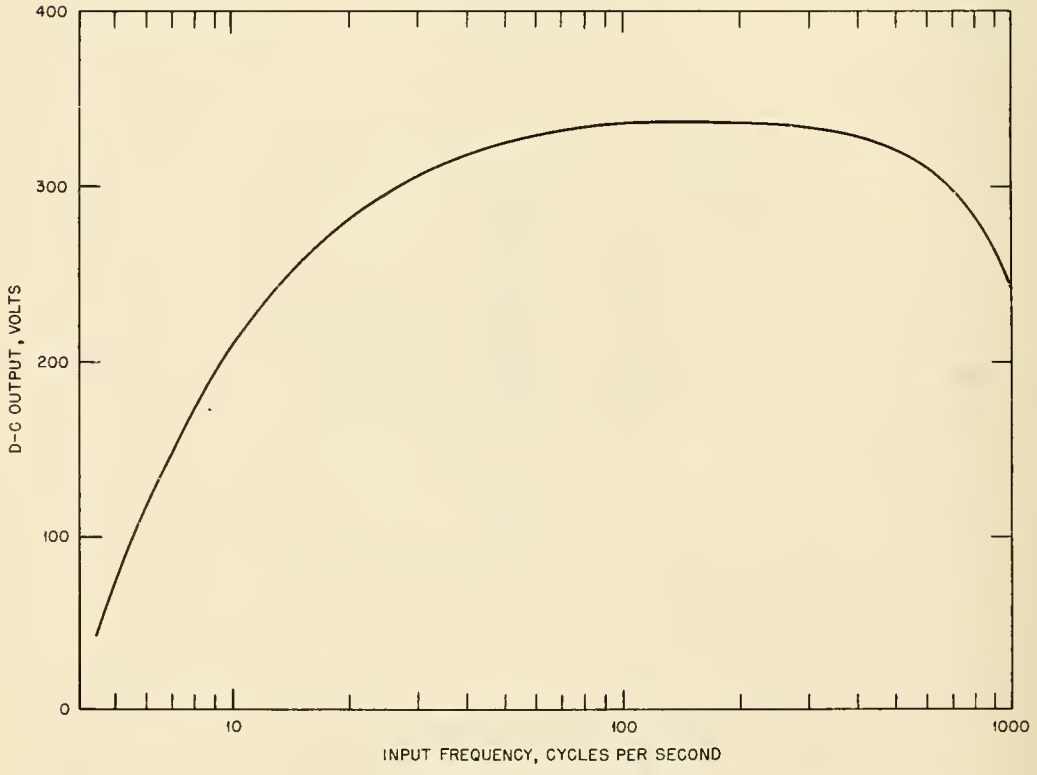

Fig. 28—Output-regulation curve.

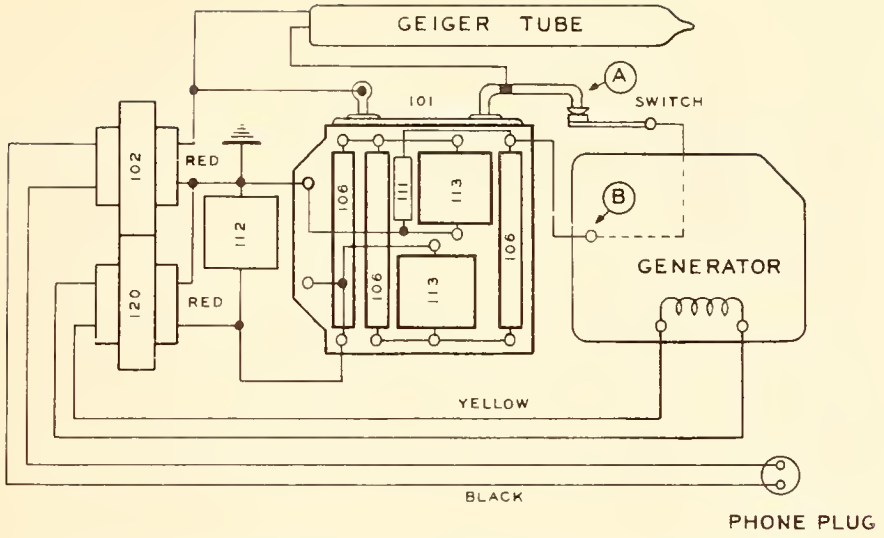

Fig. 29—Pictorial diagram of wiring. Note: Terminals A and B are check points for voltmeter and decade box, respectively. Chassis ground is common negative connection.

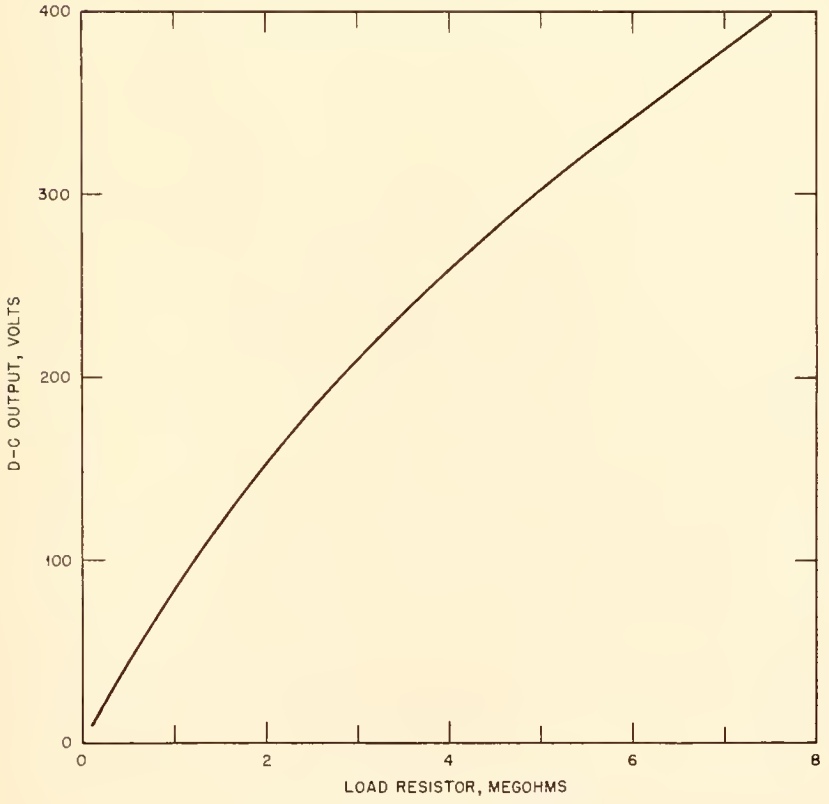

Fig. 30—Calibration-resistor chart.

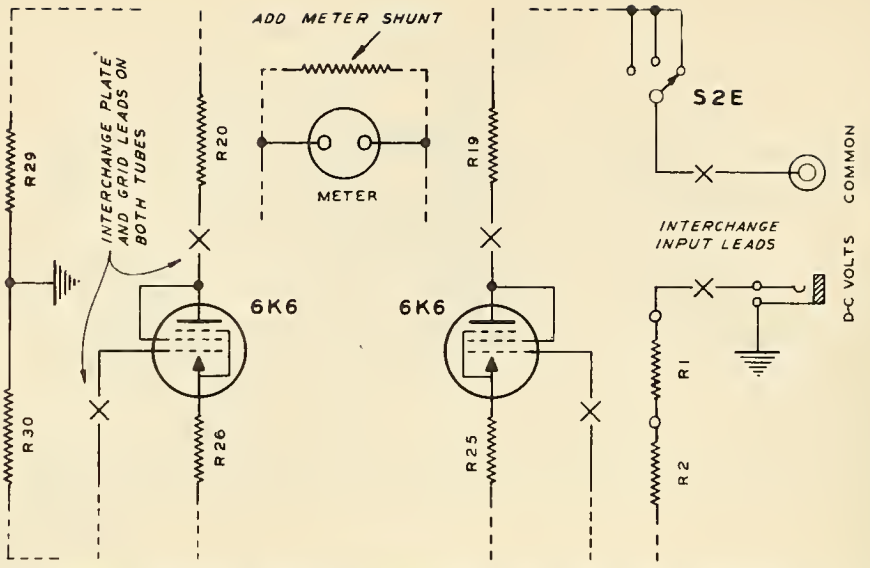

Fig. 31—Schematic diagram of changes in voltmeter circuit. RCA junior voltohmyst, type 165-A.

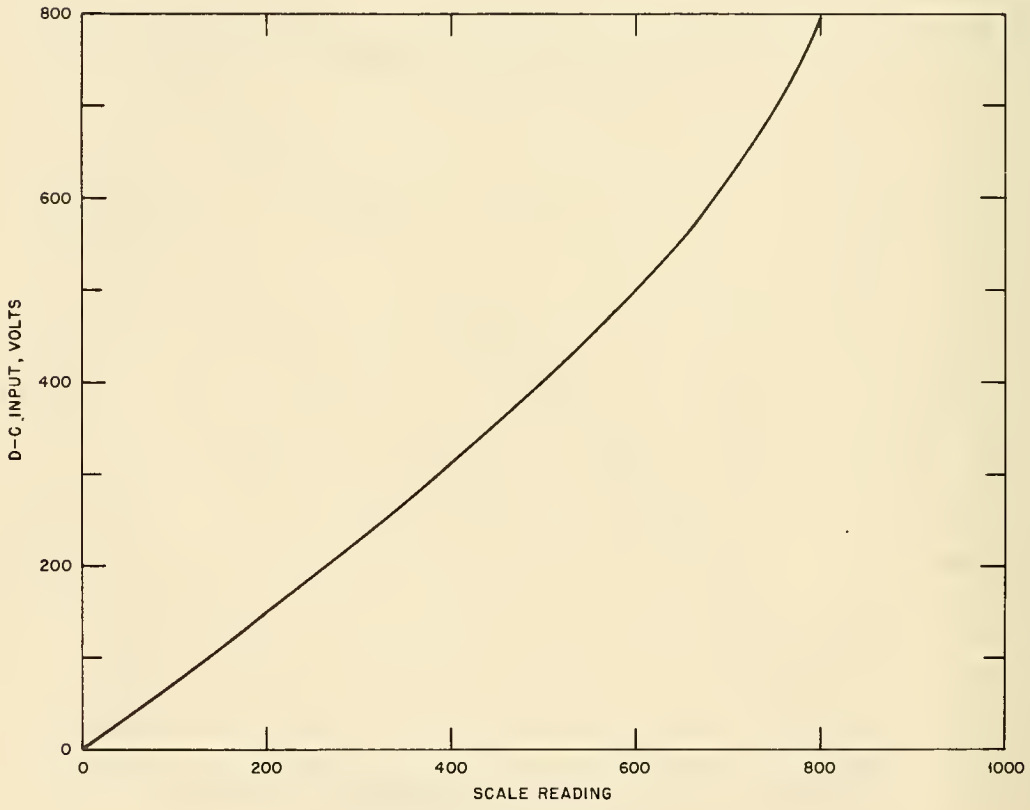

Fig. 32—Voltmeter calibration.

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